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Intervention Progress in Two Case Studies of Childhood Apraxia of Speech

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Abstract

There is a great amount of controversy surrounding childhood apraxia of speech (CAS). The most prominent issue is focused on the diagnostic criteria of which to utilize for this disorder. Because of this debate, assessment methods, along with intervention techniques, are heavily questioned. This study examines the progress children with characteristics of CAS make during intervention. Furthermore, it seeks to determine if another diagnosis is possible for these children by examining the speech sound errors such children make. Two children with characteristics of CAS were the focus of this study. Data for these children was gathered from client files at a university speech and hearing clinic. More specifically, the *Goldman Fristoe Test of Articulation* (*GFTA-2*: Goldman & Fristoe, 2000) was used to collect information on intervention progress and speech characteristics of these children. The results of this study suggest that CAS is a heterogeneous disorder, in which characteristics presented by individual children may be variable, resulting in different improvement rates during intervention. Furthermore, this suggests that there may not be a single diagnostic feature to utilize in the diagnosis of CAS.

Introduction

There is a great controversy surrounding childhood apraxia of speech (CAS), a motor planning disorder without any neuromuscular deficiencies (American Speech-Language and Hearing Association [ASHA], 2007b). Because the ability to plan motor movements is affected, the coordination required to move all articulators during speech is a difficult task for such children, resulting in impaired speech production. In addition to the great amount of disagreement concerning appropriate assessment and treatment methods to utilize for children with this disorder, the most prominent issue appears to be focused on the diagnostic characteristics of the disorder. One reason for this debate is the lack of sufficient research surrounding the disorder; however, even research that does exist is heavily questioned. Additionally, the lack of evidence to differentiate CAS symptoms from those of children with phonological and other motor speech disorders continues to be a challenge, preventing the progression of research on this disorder.

According to ASHA (2007b), the etiology of CAS can be attributed to neurological deficits. Additionally, there appears to be a possible heritability factor attributed to the acquisition of the disorder (Shriberg & Aram, 1997). The 3:1 ratio of boys to girls diagnosed with this disorder further supports the possibility of a heritability aspect, suggesting the disorder may be X-linked (Shriberg & Aram, 1997). Therefore, this also suggests that if CAS is X-linked, it would be a recessive trait. This would make males more susceptible to this disorder because if the gene for CAS is carried on the X chromosome, their X-Y chromosomal make-up would mean they only need one instance of the gene to present the disorder. Conversely, females would need two instances of the gene in order to present the disorder, because of their X-X chromosomal make-up. Even if females contained one instance of the recessive gene, it could be canceled out by a dominant gene on the other X chromosome. However, the actual etiology of CAS still remains a mystery, and a direct cause for the disorder has yet to be discovered. The prevalence of the disorder, as stated by Shriberg and Aram (1997), is about 1-2 children out of 1,000. However, considering the controversy surrounding this disorder, such statistics can be questioned and therefore the actual prevalence remains unknown.

Although there is no validated list of diagnostic criteria for CAS, there appears to be some characteristics of the disorder that are generally agreed upon. Shriberg and Aram (1997) explain that the speech errors of children with CAS "a) Differ from the errors of children with developmental speech delay and b) Resemble the errors of adults with acquired apraxia of speech" (p. 273). Additionally, ASHA (2007b) describes three characteristics of CAS, which are: "(a)inconsistent errors on consonants and vowels in repeated productions of syllables or words, (b) lengthened and disrupted coarticulatory transitions between sounds and syllables, and (c) inappropriate prosody, especially in the realization of lexical or phrasal stress" (p. 2). However, it is important to remember that these are not definite signs of CAS, as the characteristics of the disorder vary with age and among individuals. Lewis, Freebairn, Hansen, Lyengar, and Taylor (2004) suggest that the variation in symptoms may be a logical explanation for the current lack of accepted diagnostic markers for CAS, which arguably remains the largest controversy of the disorder. ASHA (2007a) additionally contributes the alternating symptoms of CAS, as the child develops, to the lack of evidence and difficulties in research within the disorder. Furthermore, there is great difficulty finding supporting evidence to make a distinction between children with CAS from those with phonological disorders

(Velleman, 2003). In fact, "the differentiation of childhood apraxia of speech from severe phonological disorder is a common clinical problem" (Bahr, 2005, p. 254). Therefore, without validated defining characteristics and specific diagnostic markers, the diagnosis of CAS, and therefore treatment methods, remains in debate.

In addition to the difficulties differentiating CAS from phonological disorders, the lack of verified symptoms of CAS also contributes to the many discrepancies of the disorder, including diagnosis and intervention. One problem that has resulted from the conflicting symptoms is the recent over-diagnosis of CAS. ASHA (2007b) associated this with the fact that "speech-language pathologists appear to lack information about the key diagnostic characteristics of the disorder" (p. 53). In addition to the recent over diagnosis of CAS, there also appears to be many false negatives, in which children who actually have CAS are not diagnosed (ASHA, 2007b). Because of this, ASHA (2007b) cautions clinicians in the diagnosis of the disorder and the terminology they use.

The controversy concerning the diagnostic markers of CAS continues even further when deciding if CAS should be classified as a unitary disorder, syndrome, or possibly subtypes. Velleman (2003) defines a unitary disorder as one that has a verified list of symptoms. She goes on further to explain that a range of symptoms may be present within a syndrome, which could be used to determine different degrees of disorder. Because of this, CAS can either be classified as having a range of symptoms, which creates the possibility of different forms of the disorder, adding to the already existing controversy. Shriberg and Aram (1997) state that CAS is defined by a symptom cluster, where it is not necessary to have all characteristics for a diagnosis. Additionally, the idea of CAS subtypes is suggested by Shriberg and Aram (1997), who discuss that there may be "different behavioral characteristics associated with diagnostic criteria for each of two or more subtypes of the disorder" (p. 276). However, all of these different perspectives, along with the lack of verified symptoms, contribute to the debate surrounding CAS.

Amongst all this controversy, however, there have been additional features of CAS that seem to be commonly agreed upon and aid with intervention techniques. For example, Velleman (2003) states that children with CAS show minimal progress in therapy, as well as problems with literacy. Because of this, one can see the need for intensive therapy for children with CAS. Strand, Stoeckel, and Baas (2006) additionally support the need for frequent and intensive treatment. It is known that the CAS also occurs early in development, which therefore suggests the need for early intervention to remediate speech and language impairments as soon as possible. However, despite the few agreed upon aspects of CAS, there are still many unanswered questions that need to be acknowledged in further research.

Regardless of the lack of concrete evidence for CAS, clinicians are still responsible for diagnosing and treating children with CAS. There have been many suggestions concerning the diagnosis of CAS. For example, ASHA (2007b) states that the repetition of syllables, as well as the production of alternating syllables, is often used to diagnose the speech motor behaviors of CAS. Forrest (2003) additionally lists inconsistent productions, general oral-motor difficulties, groping, inability to imitate sounds, increased error with increased utterance length, and poor sequencing of sounds, as the most commonly used characteristics for diagnosis among clinicians. Caruso and Strand (1999) explain potential assessment procedures to use in order to diagnose children with motor speech disorders, including CAS. These authors stated that a "major goal of assessment is often to come to a diagnosis or label for a person's communicative disorder" (p. 74). However, the controversy surrounding CAS makes it difficult to appropriately diagnose the disorder. Furthermore, Caruso and Strand (1999) state that the individual variation of symptoms among children creates for an even greater difficulty in diagnosing CAS.

Assessing the patient's history, along with an examination of the child's neuromuscular status as well as a structural-functional examination, motor speech examination, and a description of the child's sound system are all recommended procedures in an assessment according to Caruso and Strand (1999). The history of the patient is important to determine any additional factors that may be affecting the child's speech, such as underlying medical conditions. It is suggested that a clinician complete a full case history including medical, family, and developmental histories as well as an analysis of communication skills and other such elements of the child's life. The neuromuscular evaluation is important in differentiating CAS from dysarthria. Additionally, the structural-functional examination, according to Caruso and Strand (1999), allows the clinician to determine if the child has an oral apraxia or not. Assessing the difficulties the child possesses with the planning and sequencing of speech can be done during a motor speech examination. Lastly, obtaining a description of the sound system, as mentioned by Caruso and Strand (1999) is important in determining the proper treatment methods to use for children with CAS.

After a child has been diagnosed with CAS, it is important for the clinician to determine the proper treatment methods in order to successfully assist the child in his speech production. In addition to determining the type, frequency and length of treatment, Caruso and Strand (1999) state that it is first important to determine the child's level of speech (or the likelihood that they will speak) and to then set appropriate goals for the child.

Due to the debate surrounding CAS, many clinicians have different perspectives on how to properly treat the disorder. There are four categories of treatment methods according at ASHA (2007b): 1) therapies based on linguistic disorders, 2) motor-programming, 3) a combination of linguistic and motor-programming approaches, and 4) approaches based on sensory and gestural cueing are all hypothesized to be effective for children with CAS. However, the lack of evidence for this disorder, as well as the variability among children with CAS, creates even greater difficulties in determining the appropriate treatment for such children (Caruso & Strand, 1999). Therefore, there is currently not one treatment method for CAS that is completely agreed upon. Rather, only the perspectives and theories of many professionals exist.

Intervention methods utilizing the principles of motor learning appear to be a useful therapy technique for children with CAS. This intervention approach is thought to guide how the motor system learns and therefore improve the speech and language capabilities of children with CAS (Hall, Jordan, & Robin, 2006). Gildersleeve-Neumann (2007) explains the four principles of motor learning as: precursors to motor learning, conditions of practice, feedback, and effects of rate. The two most important aspects of motor learning, according to Hall et al. (2006), include the structure of the practice, and the nature of feedback.

Integral stimulation is one treatment approach proposed by Caruso and Strand (1999) for treating children with CAS. This method of treatment focuses on imitation through the use of both auditory and visual models and uses the principles of motor learning. The main emphasis of integral stimulation is repetition, because it is believed that "unless the child is given the opportunity to practice the movements required for speech, they will not make progress" (Caruso & Strand, 1999, p. 128). Additionally, the factors that make up integral stimulation are the "[manipulation of] the parameters that affect motor learning, such as frequency and nature of practice opportunities and knowledge of results and performance" (ASHA, 2007b, p. 51). As Gildersleeve-Neumann (2007) states, integral stimulation is the "watch me, listen, do as I do" method. This type of treatment method is thought to be appropriate for children with CAS because it utilizes a hierarchy approach in order to practice articulator movements for speech (Caruso & Strand, 1999). The hierarchy is important in treatment because it allows the clinician to decide how much support is needed in order for the child to achieve their goals (Gildersleeve-Neumann, 2007). However, in order for this treatment to be effective, it is imperative that the child maintain both attention and eye contact with the clinician, in order to see and imitate facial movements. Therefore, it can be assumed that integral stimulation may not be effective for a child with CAS who may also have an underlying cognitive deficit impairing either of these processes. However, for a child with just a sensorimotor planning/ programming disorder, this treatment may be effective because of its emphasis on motor learning.

Another form of treatment thought to benefit children with CAS includes tactile-kinesthetic, rhythmic, and gestural approaches (Caruso & Strand, 1999). When using the tactile-kinesthetic approach, Caruso and Strand (1999) mention the use of the moto-kinesthetic speech training, speech facilitation, and the PROMPT system as potential treatment methods. Such treatment approaches are thought to be useful for children with CAS because they "clarify movement parameters, amplitudes, trajectories, and durations" (Caruso & Strand, 1999, p. 149). In addition, the rhythmic method is also thought to be useful for children with speech motor disorders, such as CAS. This method provides a timing structure in order to facilitate speech, as many children with CAS are believed to have a disordered rhythmic structure (Caruso & Strand, 1999). Lastly, gestural methods are also thought to be a successful treatment method for children with CAS, as it is used "both to pace speech production and to provide supplementary cues regarding vocal tract shapes and movement trajectories of the articulators" (Caruso & Strand, 1999, p. 175). Although tactile-kinesthetic, rhythmic, and gestural approaches are thought to help children with CAS, such treatment methods require cognitive skills within the normal range. Therefore, it can be assumed that like integral stimulation, these approaches are not suited for all children with CAS. They may only be useful for certain subtypes, especially because many children with CAS have additional underlying disorders that may also be affecting their performance.

Lastly, dynamic temporal and tactile cueing (DTTC) is another approach discussed by Strand et al. (2006), which works on frequent, intensive treatment and practice of oral movements for effective speech production. During this approach, the clinician aids the child in attaining appropriate articulatory positions, and the child is to maintain such positions in order to "maximize proprioceptive processing" (Strand et al., 2006). Like the integral stimulation approach, DTTC also uses imitation as a method of treatment, in order for the child to work on automaticity. Additionally, similar to the hierarchy technique of integral stimulation, DTTC utilizes a similar approach by progressively weaning the amount of feedback the child receives from the clinician, as progress in treatment is made. However, because DTTC requires adequate cognitive skills in order for the treatment to be effective, it may only be appropriate for some cases of CAS.

Although there are many potential treatments that have been researched for CAS, there is not one treatment that can be used for all children diagnosed with the disorder. With the potential subtypes and variability among children, it would be nearly impossible to find one universal treatment. There are also additional issues with the current treatment methods that have been proposed. For example, ASHA (2007b) states that it is very difficult to generalize any of the results gathered from treatment research because many of the experiments took place in a clinic, rather than in a school setting. Another limitation of the current research on intervention is that “no treatment method in CAS has focused on culturally and linguistically diverse populations” (ASHA, 2007b, p. 48). Because of these factors, clinicians face even greater difficulties when deciding which treatment method would aid a child with CAS the most. However, due to potential co-existing disorders that may occur with CAS, the variance among children, and the possibility of subtypes, it is always important to keep in mind that all treatment methods need to be individualized to meet the different needs of every child.

Responding to the variance in intervention methods used by clinicians to treat children with CAS, and the limited improvement children with this disorder typically make, this study looks at the progress and error patterns that two children, with characteristics of CAS, made during speech therapy. First, the focus is not on the type on intervention, but rather the children’s individual progress. Furthermore, this study will focus on two common features associated with CAS. One characteristic of CAS is the slow progress seen during intervention. Additionally, children with CAS often make a number of errors during speech production. Therefore, the two questions addressed in this study are as follows: (1) Will there be limited progress reported over the period of treatment for these children? (2) Will the patterns of the children's speech sound errors suggest a diagnosis other than CAS? These questions were addressed by compiling information on a single assessment tool utilized for both children during three time periods and evaluating the progress these children made between the different assessment periods.

Methods

This study examined the client records of two preschool children who had received speech and language services at the University of Connecticut Speech and Hearing Clinic (UCSHC). Both children had been given the diagnosis of childhood apraxia of speech by their birth to three service providers. However, this diagnosis was later changed to "severe phonological disorder" after the children were assessed by a certified speech language pathologist (SLP) working in the UCSHC. The SLP reported that the diagnosis of these children had been altered to comply with accepted terminology at the time these children were assessed. At this time period, some professionals believed that the diagnosis of CAS may not have been appropriate and therefore, such children were given the diagnosis of a severe phonological disorder. This alteration in diagnostic terminology may have been a result of the reported over-diagnosis of CAS, as reported by ASHA (2007b). Conversely, because the distinction between a severe phonological disorder and CAS is not clearly defined, the two diagnoses may have been used interchangeably. Furthermore, Lewis et al. (2004) stated that "speech sound disorders that were first diagnosed as CAS may have been reclassified as phonology disorders during the course of remediation" (p. 123). Debatably, the most probably cause for the alteration of diagnostic terminology for these children may be that the diagnosis of CAS may not be applicable for infants and toddlers (Davis & Velleman, 2000). It has been argued that the diagnosis of CAS can not be effectively made in the infants and toddler population, especially those who are speech delayed, because such children cannot possibly have the clinical characteristics for such a diagnosis (Davis & Velleman, 2000) Therefore, it may be possible that at the time these children were assessed, CAS was not viewed as an appropriate diagnosis according to their age and language development.

Data collection

The files of seven children were reviewed by the author. These files were obtained from the archives of the university speech and hearing clinic. The files were screened for the inclusion of client histories, intervention goals, and assessment methods. Only the files for two children were identified for inclusion in this study because data from the *Goldman Fristoe Test of Articulation* (*GFTA-2*: Goldman & Fristoe, 2000) was consistently used to monitor progress throughout the children's intervention period. No other files contained more than the initial assessment of the children using either the *GFTA-2* or some other measure of speech intelligibility. In addition to raw and standard scores of the *GFTA-2*, a phonetic inventory, syllable shapes, as well as documented feature errors were analyzed through the information recorded using this assessment tool.

Child 1:

Child 1 was a male, who was first seen in the UCSHC at the age of 2 years, 3 months. The child was previously diagnosed with CAS by his birth to three service provider. However, after assessment at the UCSHC, the child's diagnosis was changed to a severe phonological impairment. The child reportedly suffered from frequent ear and sinus infections and received pressure equalizing tubes for ear infections at 22 months. Other than these frequent infections, no additional hearing concerns were reported and all audiological tests were within the normal range at all assessment periods. It was additionally noted that the child was diagnosed with Beckwith-Wiedemann syndrome at birth, which is "a genetic disorder with abdominal wall defects, gigantism, and macroglossia as its main characteristics" (Van Borsel, Morlion, Van Snick, & Leroy, 2000, p. 202). According to the SLP in the clinic, this child did not demonstrate an enlarge tongue, referred to as macroglossia in the definition of the disorder, which could have affected articulation. Mild hemihypertrophy, where the limbs of one side of the body are larger than the other (Hamada, Takada, and Kioki, 2003), was also noted at birth. The child's developmental milestones appeared to be delayed. He began sitting at 7 months, crawling at 11-12 months and walking at 16 months. His speech development was additionally delayed. The child's main deficits were in limited utterance length, a restricted sound inventory, delayed onset of speech, and reported loss of previously spoken words, which are all characteristics of CAS. It was recommended that the child receive 60 minutes of therapy 2 to 3 times a week.

The raw and standard scores for Child 1 on the *GFTA-2* can be found in Table 1. The child's standard scores fell between -2.5 to -3.0 standard deviations for all three assessments. The scores of this child demonstrated a severe speech sound impairment and initial qualification for services within the clinic. There was a three month period between assessment 1 and 2, and a 10 month period between assessment 2 and 3.

Table 1. Goldman Fristoe Test of Articulation Scores (Child 1)

	Scores	
Age	Raw Score (Total # of Errors)	Standard Score
2;10	62	57
3;1	65	56
3;11	54	58

Child 2:

Child 2 was a male first seen in the UCSHC at 2 years, 6 months. The child was initially diagnosed with apraxia of speech by his birth to three service provider. However, after assessments at the university clinic were completed, this child was diagnosed with a severe phonological disorder. Other than an ear infection at 18 months, no reported underlying medical conditions existed. After audiological testing, results were confirmed to be within the normal range. The child's developmental milestones appeared to be within the normal ranges as well. He began sitting at 4 months, crawling at 5 months and walking at 12 months. His speech ability was the only milestone that appeared delayed. This child was reported to have difficulties with conversational speech. He was receiving birth to three services for one hour weekly. In addition, he was being seen in the clinic for one hour a week. Because of the child's delay in language, he was reported to use sign language and gestures to communicate.

The raw and standard scores for Child 2 on the *GFTA-2* can be found in Table 2. The child’s standard scored placed him greater than 1 standard deviation below the mean at Time 1, but subsequent test scores were within normal limits at Times 2 and 3. However, this child was reportedly eligible for services due to his impairments in conversational speech. The results of the GFTA-2 indicate that this child was able to produce the single-word targets; however, this assessment does not include spontaneous speech measurements. Therefore, the *GFTA-2* may lack sensitivity in identifying children with limited conversational speech abilities. There was a seven month period between assessments 1 and 2, and an eight month period between assessments 2 and 3.

Table 2. Goldman Fristoe Test of Articulation Scores (Child 2)

	Scores	
Age	**Raw Score** (Total # of Errors)	**Standard Score**
3;4	40	80
3;11	26	96
4;7	20	96

Procedure

All data for this study were gathered from the *GFTA-2* results found in the files of the two children. The information from three different assessment time periods was collected. Because the assessment had been administered by different clinicians, raw scores and standard scores were rescored by the author, using the *GFTA-2* assessment handbook for converting raw scores to standard scores.

In addition to these scores, a phonetic inventory was analyzed from the productions of the 53 target words on the assessment of the two children. Since the analysis was interested in determining the sounds that the children could produce, phoneme substitutions and incorrect utterances for the target words were included in this inventory. Furthermore, the phonemes that the child produced were recorded, as opposed to the omitted phonemes. Data was organized by the manner of articulation (e.g., stop, fricative, nasal), along with the syllable positions that phonemes were found (initial, intervocalic, and final).

Syllable shapes were also collected based on the utterances the children made for the 53 target words on the assessment. Syllable shapes were defined as the consonant (C) and vowel (V) patterns used in each child's word productions. All utterances, including incorrect productions, were documented within the syllable shapes. This information was first collected by gathering the types of syllable shapes produced by each child and then calculating the percentage of occurrence for each syllable shape. Then the number of occurrences for each syllable shape was divided by the total number of words produced in the *GFTA-2*, which was 53, and then multiplying by 100. For example, at Time 1, Child 1 produced the CV shape 24 times. During this time period, 53 words were produced on the *GFTA-2*. Therefore, 24/53 = .453. Multiplying .435 by 100 would equal 45.3%. Therefore, this child produced the CV syllable shape 45.3% of the time at Time 1. All time periods consisted of 53 words. However, it is important to note that Child 2 only produced 52 of the 53 target words in the *GFTA-2* at Time 2. Therefore, the same procedure was utilized to calculate percentages for this time period, but the number of occurrences was divided by 52 instead of 53. This information on percentage of syllable shape occurrence for both children can be found in Appendix A.

The data from the percentage of occurrence for each syllable shape was then further analyzed to determine the syllable shape complexity. Hayes (1995) defines the complexity of syllable shapes as the production of closed syllables versus open, multisyllabic words over single syllable words, and the production of clusters versus singletons. An open syllable is one that ends in a vowel, such as a CV shape, where a closed syllable is one that ends in a consonant, such as a CVC shape. In addition, a multisyllabic word is one that contains two or more syllables (e.g., CVCV). Lastly, a cluster is a word that contains two or more consonants that occur together without a vowel in-between (e.g., CCVC). A singleton, however, is a word that does not contain any consonants next to each other (e.g., CVC). A complexity scale can be used to compare each syllable where closed syllables are more complex than open syllables, multi-syllabic words are more complex than mono-syllable words, and words with consonant clusters are more complex than words with singletons only. The data from the percent occurrence for each syllable shape was used to determine the percent that each child produced open and closed syllables, mono- and multi-syllable words, as well as singletons and clusters. This was done by adding up the percentages of each category, located in Appendix A. For example, to calculate the percent of closed syllables produced for Child 1 at Time 1, the author added the 21% occurrence of the CVC shape and a 13.2% occurrence of the CVVC shape, which are both closed syllable shapes. Therefore, at Time 1, Child 1 produced closed syllables 34.2% of the time. This same method was utilized to determine the percentage of open syllables, multi- and mono-syllable words, as well as singletons and clusters.

Lastly, the type of feature errors the children made for incorrect utterances were recorded. These errors focused on the type of substitution the children made and did not include omission errors. A distinctive features chart was used to determine which type of error was produced. The percentage of occurrence for each feature error was additionally calculated for each time period. This was done by first determining how many total errors had been made at individual time periods. Next, the author divided each type of feature error by the total number of errors and multiplied by 100. For example, at Time 1 for Child 1, the substitution of a [+ continuant] to a [–continuant] occurred 7 times. During this time period the child made 38 total errors on the *GFTA-2*. Therefore, 7/38 = .184. Multiplying .184 by 100 would equal an 18.4% occurrence of the child substituting a continuant for a non-continuant sound. The descriptions for each type of feature error can be found in Appendix B, which utilizes the definitions provided by Halle and Clements (1983, p. 6-8).

Results

Child 1

Phonetic Inventory

The phonetic inventory for Child 1 can be seen in Table 3. The data gathered from the child's productions on the *GFTA-2* revealed slight progress between Times 1 and 3. This child demonstrated consistent production of most initial stop consonants throughout all three time periods. In addition, Child 1 successfully produced the initial glides /j/ and /w/ consistently throughout all assessment times. Nasals appear to be correctly produced throughout all assessments, with the exception of /n/ in the intervocalic position at Time

1 and /ŋ/ in the intervocalic and final positions at Times 2 and 3, which appeared to regress after the initial time. However, fricatives and affricates in all syllable positions appear to be the most impaired. Additionally, this child demonstrated difficulties with intervocalic and final positions for stops.

The most significant improvements this child appeared to make were on the initial affricate phonemes /ʧ/ and /ʤ/. Other than this, only minimal improvements were seen. For example, the production of word final /b/ that emerged at Time 3, which had not previously occurred at Times 1 and 2. Also, the slight improvement in the production of liquids from the initial to final assessment was seen in the phonetic inventory. Overall, however, this child appeared to be making minimal progress. This slow improvement was also supported by the raw and standard scores on the *GFTA-2*. As seen in Table 1, Child 1 showed an increase in the number of errors made, going from 62 at Time 1 to 65 at Time 2. However, although the number of errors at Time 3 did decrease to 54, the standard score of 58 did not show improvement compared to the standard score of 57 at Time 1 and 56 at Time 2. Therefore, this child's progress was minimal over a 13 month period.

In addition to demonstrating the lack of progress that this child made between Times 1 and 3, Table 3 also depicts the areas of difficulty for Child 1. For example, manners of production, especially affricates and fricatives, appeared to be the most impaired categories. In addition, intervocalic and final consonant positions were problematic for this child. Consequently, this child demonstrated little to no progress within these areas even with 13 months of therapy.

Table 3. Phonetic Inventory (Child 1)

		Age of Child		
		2;10	**3;1**	**3;11**
Manner:	**Syllable Position:**			
Stop	Initial	/b,t,d,k,g/	/p,b,t,d,k,g/	/p,b,t,d,k,g/
	Intervocalic	/t/	0	/t/
	Final	/t/	0	/b,t/
Nasal	Initial	/m,n/	/m,n/	/m,n/
	Intervocalic	/m/	/m,n/	/m,n/
	Final	/m,n,ŋ/	/m,n/	/m,n/
Fricative	Initial	0	/h,s/	/h,z/
	Intervocalic	0	0	/ð/
	Final	0	0	0
Affricate	Initial	0	0	/ʦ, ʤ/
	Intervocalic	0	0	0
	Final	0	0	0
Glide	Initial	/j,w/	/j,w/	/j,w/
	Intervocalic	-	-	-
	Final	-	-	-
Liquid	Initial	/l/	/l/	/l,r/
	Intervocalic	0	0	/l/
	Final	0	/r/	/l,r/

Note: a symbol - indicates that phonemes do not exist in syllable positions
Note: a symbol 0 indicates that the child did not produce any phonemes in those syllable positions

Syllable Shapes

The results of the syllable shape complexity produced by Child 1 for the 53 target words on the *GFTA-2* are included in Table 4. The information collected demonstrates the child's slight progress in producing increasingly more complex syllable shapes. For example, from Time 1 to Time 3, the child decreased the number of open syllables produced from 66% at Time 1 to 54.6% at Time 3. As a result, the number of closed syllables increased from 34.2% at Time 1 to 42.2% at Time 3. As reported by Halle and Clements (1983), the production of closed syllables over open syllables is more complex. Furthermore, Child 1 made improvements between Time 1 and Time 3 in his production of multisyllabic words. At Time 1, this child produced multisyllabic words 11.3% of the time. However, at Time 3, he produced these words 20.7%. It is well known that the production of multisyllabic words is more complex than single syllable words (Halle & Clements, 1983); therefore, this child demonstrated some progress in his syllable shape complexity. This improvement is further supported by Child 1's increase in the percentage of clusters produced as well. Over all three time periods this child gradually increased the percentage of clusters produced, therefore reducing the number of singletons. At Time 1, the child had a 0% occurrence of clusters. However, at Time 2 this child had a 9.5% occurrence, which increased to a 13.2% occurrence of clusters at Time 3. Because the production of clusters is considered more complex than producing singletons, this child demonstrated an improvement in his syllable shape complexity through the 13 month intervention period.

Table 4. Syllable Shape Complexity (Child 1)

	Age of Child		
	2;10	3;1	3;11
Open Syllable	66%	75.4%	54.6%
Closed Syllable	34.2%	24.6%	45.2%
Single Syllable	88.9%	75.5%	79.1%
Multi-Syllable	11.3%	24.5%	20.7%
Singletons	100%	90.5%	86.6%
Clusters	0%	9.5%	13.2%

Feature Errors

Data concerning the types of feature errors made by Child 1 during the *GFTA-2* can be found in Table 5 (description of feature errors can be found in Appendix B).The errors that the child made varied between all time periods. However, the substitution of a [+coronal] for a [-coronal] sound appeared to be a common error throughout all three assessment periods. At Time 1, this error comprised 18.4% of all substitutions made. Most significantly, it made up 22.0% of all errors at Time 2. At time three, this child produced a [-coronal] in place of a [+coronal] sound 19.0% out of all errors. The substitution of a [+continuant] with a [-continuant] sound additionally seemed to be a common error for Child 1. This error appeared most often during Time 1, with 18.4% and at Time 3, where this substitution was made 19% of the time. At Time 2, the substitution of a [+continuant] sound with a [-continuant] sound only occurred 6.7% of the time. However, during this time period [+consonantal] sounds appeared to be more problematic for this child, in addition to [+coronal] sounds. The substitution of a [+consonantal] sound for a [-consonantal] sound appeared 20.0% out of all the errors, making it the second most occurring error for this child during Time 2. This substitution also occurred 13.2% of the time in Time 1 and 14.0% during Time 3. Therefore, the substitution of a [+consonantal] for a [-consonantal] appeared to be a common error for this child as well. This child did produce other substitutions, however their frequency was limited. Therefore, it appears that consonantal, continuant and coronal sounds were the most frequent errors Child 1 produced.

Another important piece of data represented in Table 5 is the number of total errors made during the individual time periods. As shown in the Table 5, during Time 1 the child made a total of 38 errors. At Time 2, his total number of errors increased to 45. However, at Time 3, his total number of errors decreased to 21, which is a moderate improvement from Time 2. Still, over the course of 13 months, this child's improvement from 38 to 21 may arguably not be viewed as that significant. In fact, it further demonstrates the slow rate of progress reported in children with CAS.

Table 5. Types of Feature Errors and Number of Occurances (Child 1)

	Age					
	2;10		3;1		3;11	
Error Type		% of Error		% of Error		% of Error
[+consonantal]→[-consonantal]	5	13.2%	9	20.0%	3	14.0%
[-continuant]→[+continuant]	2	5.3%	3	6.7%	0	0.0%
[+continuant]→[-continuant]	7	18.4%	3	6.7%	4	19.0%
[+voice] → [-voice]	0	0.0%	0	0.0%	1	4.8%
[-voice] → [+voice]	5	13.2%	4	8.9%	1	4.8%
[+anterior] → [-anterior]	4	10.5%	6	13.3%	2	9.5%
[-anterior]→ [+anterior]	1	2.6%	2	4.4%	2	9.5%
[-nasal]→ [+nasal]	0	0.0%	1	2.2%	1	4.8%
[-labial]→ [+labial]	4	10.5%	3	6.7%	2	9.5%
[+labial]→ [-labial]	0	0.0%	2	4.4%	0	0.0%
[-coronal] → [+coronal]	1	2.6%	1	2.2%	1	4.8%
[+coronal]→ [-coronal]	7	18.4%	10	22.0%	4	19.0%
[+lateral]→ [-lateral]	2	5.3%	1	2.2%	0	0.0%
total number of errors:	38		45		21	

Note: Number of errors do not include omission errors

Child 2

Phonetic Inventory

The phonetic inventory for Child 2 is listed in Table 6. The data gathered from the child's productions on the *GFTA-2* revealed some progress between Times 1 and 3. This child demonstrated consistent production of all stop phonemes in the initial and intervocalic positions at all time periods. He only struggled with the phonemes /b/ and /g/ at Time 1, but mastered all stop phonemes in the final position by Time 2, and maintained all productions in Time 3. In addition, Child 1 successfully produced the initial glides /j/ and /w/ consistently throughout all assessment times. Nasals were correctly produced throughout all assessments, with the exception of /ŋ/ in the intervocalic and final position at Time 1. This phoneme emerged at Time 2 and was consistently produced, along with all other nasals by Time 3. However, affricates in all syllable positions were the most impaired at Time 1. By Time 2, the child began producing /ʤ/ in the intervocalic position, and both phonemes /ʧ / and /ʤ/ in the final position at this time period. By Time 3, this child successfully produced both affricate phonemes in all syllable positions. This was the greatest progress seen in this child. Fricatives additionally appeared to be impaired at Time 1, as can be seen in Table 6. However, by Time 3, this child appeared to make improvements in these productions, especially in the final syllable position. It is also interesting to see that this child regressed in his production of the phoneme /r/ at Time 3, compared to Time 2. Therefore, some regression, although moderate, was present during the 15 month time span.

In addition to demonstrating the progress that this child made between Times 1 and 3, the phonetic inventory table also depicts the areas of difficulty for this child. For example, manner of production, especially affricates, appeared to be the most impaired category for this child at Time 1. However, significant improvements were made within 15 months of therapy. In addition, final consonant positions appeared to be most problematic for this child. Yet, throughout therapy, significant progress can be seen in most areas.

Table 6. Phonetic Inventory (Child 2)

		Age of Child		
		3;4	**3;11**	**4;7**
Manner:	**Syllable Position:**			
Stop	Initial	/p,b,t,d,k,g/	/p,b,t,d,k,g/	/p,b,t,d,k,g/
	Intervocalic	/p,b,t,d,k,g/	/p,b,t,d,k,g/	/p,b,t,d,k,g/
	Final	/p,t,d,k/	/p,b,t,d,k,g/	/p,b,t,d,k,g/
Nasal	Initial	/m,n/	/m,n/	/m,n/
	Intervocalic	/m,n/	/m,n,ŋ/	/m,n,ŋ/
	Final	/m,n/	/m,n,ŋ/	/m,n,ŋ/
Fricative	Initial	/f,v,s,□,h/	/f,v,s,z,h/	/f,v,s,z,□,h/
	Intervocalic	/f,s,z,□/	/f,v,z,□/	/f,v,s,z,□/
	Final	/f,s,□/	/f,v,s,z,□/	/f,v,s,z,□/
Affricate	Initial	0	0	/ʧ, ʤ /
	Intervocalic	0	/ʤ/	/ʧ, ʤ/
	Final	0	/ʧ, ʤ/	/ʧ, ʤ/
Glide	Initial	/j,w/	/j,w/	/j,w/
	Intervocalic	-	-	-
	Final	-	-	-
Liquid	Initial	0	/r/	/l/
	Intervocalic	0	/l,r/	/l/
	Final	/l,r/	/l,r/	/l/

Note: a symbol - indicates that phonemes do not exist in syllable positions
Note: a symbol 0 indicates that the child did not produce any phonemes in those syllable positions

Syllable Shapes

The results of the syllable shape complexity produced by Child 2 for the 53 target words on the *GFTA-2* are included in Table 7. The information collected demonstrates the child's progress in producing increasingly more complex syllable shapes. For example, from Time 1 to Time 3, the child decreased the number of open syllables produced from 57% at Time 1 to 26.4% at Time 3. As a result, the number of closed syllables increased from 43.4% at Time 1 to 73.6% at Time 3. The production of closed syllables over open syllables is more complex (Halle & Clement, 1983), therefore suggesting this child made significant progress in his syllable shape complexity as a result of intervention. Furthermore, this child demonstrated improvements in syllable shape complexity by the increased production of clusters between Time 1 and Time 3. Over all three time periods this child gradually increased the percentage of clusters produced, therefore reducing the number of singletons. At Time 1, the child had a 3.8% occurrence of clusters. At Time 2 this child had increased his production of clusters to 19.1%, which then increased significantly to a 45.3% occurrence of clusters at Time 3. Because the production of clusters is considered more complex than producing singletons, according to Halle and Clements (1983), this child demonstrated some improvements in his syllable shape complexity through the 15 month intervention period. However, this child did show regression in the production of multisyllabic words between Time 1 and Time 3. At Time 1, Child 2 had a 54.8% occurrence of multisyllabic words. This production then dropped to 34.5% at Time 2. At Time 3, the child produced multisyllabic words 47.2 % of the time. Although there was some improvement from Time 2 to Time 3, there was still a regression of production between Time 1 and Time 3.

Table 7. Syllable Shape Complexity (Child 2)

	Age of Child		
	3;4	3;11	4;7
Open Syllable	57%	17.3%	26.4%
Closed Syllable	43.4%	82.5%	73.6%
Single Syllable	45.3%	65.3%	52.8%
Multi-Syllable	54.8%	34.5%	47.2%
Singletons	96.3%	80.7%	54.7%
Clusters	3.8%	19.1%	45.3%

Feature Errors

The types of feature errors made by Child 2 during the *GFTA-2* can be found in Table 8. The errors that the child made varied between all time periods. However, the substitution of a [+coronal] for a [-coronal] sound appeared to be a common error throughout all three time periods. This error appeared to be more frequent at Times 1 and 3, where it comprised 25% of all substitutions made. This error also occurred 22.0% of the time during Time 2. The substitution of a [+continuant] with a [-continuant] sound additionally seemed to be a common error for Child 2. This error appeared most often during Time 2, with 25.7% and at Time 3, where this substitution was made 25% of the time. At Time 1, the substitution of a [+continuant] sound with a [-continuant] sound occurred 15% of the time. The substitution of a [-anterior] sound for a [+anterior] one, as well as a [-labial] for a [+labial] additionally appeared during this child's production. Further feature errors also occurred, however, they were limited in frequency.

Another important piece of data represented in Table 8 is the number of total errors made during the individual time periods. As shown in the table, during Time 1 the child made a total of 20 errors. At Time 2, his total number of errors decreased to 15. His total number of errors continued to decrease over his 15 months of therapy, to the point where he only had 8 errors by Time 3. Therefore, this child showed progress between Time 1 and Time 3.

Table 8. Types of Feature Errors and Number of Occurances (Child 2)

	Age					
	3;4		3;11		4;7	
Error Type		% of error		% of error		% of error
[+consonantal] → [-consonantal]	2	10.0%	1	6.7%	1	12.5%
[-continuant] → [+continuant]	1	5.0%	1	6.7%	0	0.0%
[+continuant] → [-continuant]	3	15.0%	4	26.7%	2	25.0%
[+voice] → [-voice]	1	5.0%	0	0.0%	0	0.0%
[-voice] → [+voice]	1	5.0%	0	0.0%	0	0.0%
[+anterior] → [-anterior]	1	5.0%	1	6.7%	0	0.0%
[-anterior] → [+anterior]	2	10.0%	3	20.0%	1	12.5%
[-nasal] → [+nasal]	0	0.0%	0	0.0%	0	0.0%
[-labial] → [+labial]	3	15.0%	1	6.7%	2	25.0%
[+labial] → [-labial]	0	0.0%	0	0.0%	0	0.0%
[-coronal] → [+coronal]	1	5.0%	1	6.7%	0	0.0%
[+coronal] → [-coronal]	5	25.0%	3	20.0%	2	25.0%
[+lateral] → [-lateral]	0	0.0%	0	0.0%	0	0.0%
total number of errors:	20		15		8	

Note: Number of errors do not include omission errors

Discussion

The purpose of this study was to evaluate the speech characteristics of two preschool children with features of CAS. In particular, the author was interested in examining the clinic folders of the children for information about patterns of errors and the amount of progress reported during their time in treatment. This information was used to determine whether the children exhibited behaviors that were consistent with the diagnosis of CAS. The results of the study indicated that Child 1 demonstrated numerous speech sound errors and showed limited progress in therapy. In comparison, Child 2 had relatively fewer errors and made significant improvement during the treatment period. Therefore, Child 1 showed characteristics consistent with the diagnosis of CAS, while it is questionable whether Child 2 met these diagnostic criteria based on the standardized measures examined. The results of children's performances on the standardized measures will be discussed in the following sections.

Severity Levels

Based on the standard scores obtained from the *GFTA-2*, Child 1's level of severity was significantly greater than Child 2 at all three assessments periods. The scores for Child 1 placed him greater than two standard deviations below the mean at all assessment periods. For Child 2, only the standard score obtained during the first assessment placed him greater than one standard deviation below the mean for children the same chronological age, while the subsequent assessments placed this child's performance within normal limits. To support these results, the phonetic inventory of

Child 1 was also significantly limited when compared to Child 2. Child 2 appeared more advanced in the production of most phonemes in comparison to Child 1. Additionally, Child 2 demonstrated more complexity of syllable shapes. From his performance, it appeared that fewer omissions were made compared to Child 1 and that Child 2 developed more complex syllable shapes throughout the course of intervention.

Patterns of Error

Syllable Shape Complexity

Overall, syllable shape complexity appeared to be significant areas of improvement for both children. As stated by Hayes (1995), syllable shape complexity is defined as the production of closed syllables as opposed to open syllables. Similarly, the production of multisyllabic words is more complex than single syllable words, and clusters are more complex than singletons. Child 1 made progress between Time 1 and Time 3 in the production of closed syllables, multisyllabic words, and clusters. Similarly, Child 2 made improvements in the production of closed syllables and clusters. However, Child 2 showed regression in the production of multisyllabic words between Time 1 and Time 3. This could be attributed to his difficulties with conversational speech, which reportedly made him eligible for services. Therefore, although Child 2 appeared more advanced than Child 1, he did not make as much progress in the production of multisyllabic words. Still, the overall percentage of closed syllables, multisyllabic words and clusters was greater for Child 2 than Child 1. Such improvements in syllable complexity in both children can be attributed to successful intervention. Consequently, although Child 1 did not appear to make significant progress overall, this data provides evidence that some improvements had been made as a result of intervention. Therefore, the lack of progress typically associated with CAS may only be associated with certain aspects of intervention. This data further suggests that syllable shape complexity appears capable of remediation during intervention for children with CAS.

Distinctive Features

Both children demonstrated similar errors with continuant, consonantal, and coronal sounds. The nature of CAS, as a motor programming disorder, may have an effect on the production of these sounds. For example, Halle and Clements (1983) define a coronal as a sound that involves raising the tip of the tongue towards the teeth or palate. It may be possible that children with CAS have difficulties coordinating the movements of the tip of the tongue needed for successful production of these sounds. Similarly, the production of continuant sounds may be impaired in children with CAS due to motor programming deficits. A continuant is a sound that is “formed with a vocal tract configuration allowing the airstream to flow through the midsaggital region of the oral tract” (Halle & Clements, 1983, p. 7). Therefore, because many systems are involved in the production of a continuant sound, including the lungs for a sustained breath, the vocal cords, and an open oral tract, it may be difficult for children with CAS to coordinate and maintain all of these systems at the same time, resulting in impaired production of these sounds. Lastly, consonantal sounds involve sustaining the constriction of the vocal tract. The motor planning deficit of CAS may not enable such children to maintain the constriction of the vocal tract for relatively long period of time. Therefore, the motor programming impairments often characterized in children with CAS may result in substitutions of coronals, continuant, and consonantal sounds.

Rate of Progress

The most notable difference between these two children is related to the first question of this study, which asked: Will there be limited progress over the treatment period for these children? After reviewing the data collected for Child 1, it is clear that little improvement was made throughout the 13 month intervention period. The raw and standard scores of the *GFTA-2* for this child further supported the lack of progress made. Additionally, the child's minimal improvements of his phonetic inventory demonstrated slow rate of change. However, this child did make improvements in reducing the total number of substitution errors on the assessment from 38 at Time 1 to 21 at Time 3. The child did regress in his abilities at Time 2, where he produced 45 total errors. The most significant improvements appear to be in Child's increasing syllable shape complexity. Progress was seen in the production of open syllables, multisyllabic words, and in cluster productions. However, considering the 13 month period of intervention, these results were made at a slow rate. Overall, the results for Child 1 demonstrated characteristics of CAS, including a slow rate of progress throughout intervention, along with variability of errors.

The analysis of the data for Child 2, in comparison to Child 1, however, is significantly different and complicates the issue of CAS even further. As oppose to Child 1, Child 2 appears to make significant progress throughout his 15 months of intervention. After the initial assessment, Child 2 consistently improved his scores on the *GFTA-2* at all time periods. Furthermore, this child progressively reduced the total number of substitution errors made during the 15 month assessment period. He went from producing 20 errors at Time 1, to only 8 errors at Time 3. Furthermore, Child 2 had significantly more progress in the syllable shape complexity concerning closed syllables and cluster productions. The only area that did not see significant progress was in the production of multisyllabic words. However, Child 2 did begin to make progress from his initial regression at Time 2. Therefore, the results of Child 2 do not support the lack of progress reportedly seen in children with CAS.

There may be multiple explanations for the differences in progress associated with both children. The first is that Child 1 lacked motivation and was not interested in attending his therapy sessions, as reported by the SLP working with him. Because of these factors, the child often missed intervention sessions. Therefore, the combined lack of motivation and missed therapy sessions may have influenced the limited progress seen with this child. As stated by Strand et al. (2006), frequent and intensive therapy is needed for children with CAS. Therefore, if this child was missing intervention sessions, there was a lack of consistency in therapy, which may have resulted in the limited improvements. Another possible explanation for lack of progress seen with Child 1 is the underlying medical condition, Beckwith-Wiedemann syndrome. It is possible that some of the symptoms associated with this disorder may have had an influence on the child's speech and language abilities. No information regarding the effects of this disorder on the child's language impairment or diagnosis was found within the child's file, possibly suggesting that this disorder did not have an influence on the language characteristics of the child. Furthermore, it is possible that the frequent ear infections during Child 1's first

2 years may have contributed to his language delay, but at the time of all assessment periods the child's hearing was within the normal range. One other possible explanation for the differences seen in both children is that Child 2 may not have actually had CAS. It is possible that the progress seen in therapy may indicate that this child just had a severe phonological disorder and not CAS. However, another possibility is that CAS may be a heterogeneous disorder, where there may be many different ways in which the characteristics can be displayed, and that no single feature may be possible to make the diagnosis of CAS.

Do the Children Show Patterns Consistent with CAS?

As explained by Forrest (2003), clinicians use a variety of characteristics to make the diagnosis of CAS. In their study, where 75 SLPs were surveyed, a total of 50 different characteristics were utilized by different clinicians to diagnose CAS. The most commonly cited characteristics included inconsistent productions, general oral-motor difficulties, groping, inability to imitate sounds, increased error with increased utterance length, and poor sequencing of sounds (Forrest, 2003). In addition, low phonemic inventory, slow progress in therapy, and frequent sound omissions were noted as characteristics of CAS (Forrest, 2003). The ambiguous criteria used by a variety of clinicians to diagnose CAS may suggest possible heterogeneity of the disorder. Therefore, it may be probable that while Child 2 made progress, it does not mean that he did not demonstrate other features of the disorder, which would justify the diagnosis. For example, the child's reported difficulties with conversational speech would demonstrate his poor ability in sequencing sounds, which is a common feature of CAS. Furthermore, the child may have demonstrated other characteristics that were not evident from the results of the *GFTA-2* assessment used in this study. Therefore, other characteristics may have been present that were not deduced from the results of this study. Arguably, however, the most probable cause for the differences seen in intervention for these two children may be due to the possible heterogeneous nature of CAS.

The second question of this study asks if the patterns of the children's speech sound errors suggest a diagnosis other than CAS. Hall et al. (2006) stated that children with CAS may have errors in sound class and manner of productions, errors types such as omissions and substitutions, and difficulties sequencing phonemes and syllables. Both children in this study exhibited all of these features. Child 1 was more impaired than Child 2 overall, as discussed earlier. However, both children demonstrated difficulties with affricates and fricatives more than the other manners of production. Additionally, both children made omission and substitution errors. Although omission errors were not specifically recorded in this study, such errors can be interpreted by the limited complexity of syllable shapes in both children in comparison to the syllable shapes found in the *GFTA-2.* Both children also made multiple substitution errors within the *GFTA-2*. The most significant errors in both children appeared to be with coronals, consonantal sounds and continuant sounds. Lastly, the syllable shapes data demonstrated the difficulties both children had in sequencing phonemes and syllables. Although Child 2 appeared to be less impaired in his syllable shapes production than Child 1, his syllable shapes did not sufficiently match those on the *GFTA-2*. However, this difficulty in sequencing would be expected by the reported impairments this child has in conversational speech.

Although both children display many speech errors related to CAS, there are many that are not as prevalent in these children. For example, nasality and emission errors, vowel errors and voicing errors, as stated by Hall et al. (2006). Although the children did make a few voicing errors, they were not as frequent as other errors. In addition, nasal errors were not as frequent, or did not occur at all for Child 2. Most significantly, although it appeared Child 1 did not make significant progress during intervention, some progress in syllable shape complexity was observed, which does not support the lack of progress typically seen in children with CAS. Therefore, the possibility of a diagnosis other than CAS may be possible. However, a more likely hypothesis is that CAS is a heterogeneous disorder, as discussed previously. Therefore, although both children display varying characteristics of CAS, it is possible that the disorder contains many features and that individuals may present these characteristics differently. More importantly, it may be possible to suggest that a child does not need all the characteristics of CAS to be given the diagnosis. As evident by the two children in this study, there may also be various degrees of the disorder, and therefore differences in progress made during intervention may be possible.

Limitations

This study, like much research concerning CAS, does not come without limitations, which may have affected the analysis of these two children. First, and most significant, is that all *GFTA-2* assessments for both children had been administered by different clinicians and graduate students within the clinic. Therefore, there was a lack of consistency within the recordings and potential differences in the interpretations of the child's productions among clinicians. Furthermore, because no speech samples or recordings of the children during their assessments were available, their productions on the *GFTA-2* could not be reevaluated by the investigator. Another limitation of this study is the use of the *GFTA-2* as the sole assessment measure utilized. As seen in Child 2's standard scores on this assessment, the *GFTA-2* does not analyze conversational speech. Therefore, there may be other speech characteristics of this child, along with Child 1, that could not be determined from the results of the *GFTA-2* alone. However, this assessment was utilized in this study due to the consistency of use for both children. One last limitation of this study is the alteration of the diagnosis for both children from CAS to a severe phonological disorder. Although possible suggestions were made for the reasoning behind this change, one must question if these children did actually have a diagnosis of CAS or a severe phonological disorder.

Conclusion

The goal of this study was to examine the progress children with characteristics of CAS make during speech therapy. The variance in intervention progress between the two children utilized in the study, along with the error types made, suggest that CAS may be a heterogeneous disorder. Both children demonstrated some progress during intervention. Conversely, areas of regression or slow rate of progress were also found during the period of therapy. Therefore, both children had characteristics of CAS, but their intervention progress and presentation of common characteristics of the disorder varied between them. However, it is obvious that further research needs to be conducted on CAS. In addition to determining characteristics needed to make the diagnosis of CAS, research should also focus on intervention techniques to utilize for these children. If CAS is in fact a heterogeneous disorder, as hypothesized in this study, different intervention methods may need to be utilized for individual children.

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Appendix A

Syllable Shapes (Child 1)

	Child's Age					
	2;10		3;1		3;11	
		%		%		%
Words ending in Vowels						
CV	24	45.3%	21	39.6%	12	22.6%
CVCV	5	9.4%	9	16.9%	6	11.3%
CVV	5	9.4%	4	7.5%	7	13.2%
VCV	1	1.9%	2	3.8%	0	0.0%
CCV	0	0.0%	2	3.8%	4	7.5%
CCVV	0	0.0%	1	1.9%	0	0.0%
CVCCV	0	0.0%	1	1.9%	0	0.0%
Total		66.0%		75.4%		54.6%
Words ending in Consonants						
CVC	11	21.0%	8	15.1%	12	22.6%
CCVC	0	0.0%	0	0.0%	2	3.8%
CVCC	0	0.0%	1	1.9%	1	1.9%
CVCVC	0	0.0%	1	1.9%	4	7.5%
CVVC	7	13.2%	3	5.7%	4	7.5%
VCVC	0	0.0%	0	0.0%	1	1.9%
Total		34.2%		24.6%		45.2%

Note: *GFTA-2* consists of 53 target words and the syllable shapes and number of occurrences for these words are as follows: CVC: 15; CCV: 2; CVCCV: 2; CVCVCVC: 2; CCVC: 9; CVCVC: 7; CVCVCV: 1; CVCV: 3; CVCCVC: 3; CCVCVC: 2; CVCC: 2; VCVCC: 1; CVCCVCC: 1; CCVVC: 2; CCVCC: 1

Syllable Shapes (Child 2)

	Child's Age					
	3;4		3;11		4;7	
		%		%		%
Words ending in Vowels						
CV	7	13.2%	3	5.8%	3	5.7%
CVCV	17	32.1%	3	5.8%	4	7.5%
VCV	1	1.9%	0	0.0%	0	0.0%
CCV	0	0.0%	0	0.0%	2	3.8%
CVCCV	0	0.0%	2	3.8%	4	7.5%
CVVCV	1	1.9%	0	0.0%	0	0.0%
CVCVCV	0	0.0%	1	1.9%	1	1.9%
CVCVCVCV	1	1.9%	0	0.0%	0	0.0%
CVCVCVCV	3	5.7%	0	0.0%	0	0.0%
Total		56.7%		17.3%		26.4%
Words ending in Consonants						
C	0	0.0%	2	3.8%	0	0.0%
CC	0	0.0%	3	5.8%	0	0.0%
CVC	15	28.3%	22	42.3%	12	22.6%
CCVC	0	0.0%	0	0.0%	9	16.9%
CVCC	2	3.8%	2	3.8%	2	3.8%
CVCVC	6	11.3%	9	17.3%	5	9.4%
CVVC	0	0.0%	2	3.8%	0	0.0%
CCVCC	0	0.0%	0	0.0%	1	1.9%
CCVVC	0	0.0%	0	0.0%	2	3.8%
CCVCVC	0	0.0%	0	0.0%	2	3.8%
CVCVCC	0	0.0%	1	1.9%	1	1.9%
CVCCVC	0	0.0%	2	3.8%	3	5.7%
CVCVCVC	0	0.0%	0	0.0%	2	3.8%
Total		43.4%		82.5%		73.6%

Note: *GFTA-2* consists of 53 target words and the syllable shapes and number of occurrences for these words are as follows: CVC: 15; CCV: 2; CVCCV: 2; CVCVCVC: 2; CCVC: 9; CVCVC: 7; CVCVCV: 1; CVCV: 3; CVCCVC: 3; CCVCVC: 2; CVCC: 2; VCVCC: 1; CVCCVCC: 1; CCVVC: 2; CCVCC: 1

Note: At Time 2 Child 2 only made 52 productions out of the 53 target words of the GFTA-2

Appendix B

(7) **The Articulatory Correlates of the Distinctive Features**

1. **syllabic/nonsyllabic:** [±syl]. Syllabic sounds are those that constitute syllable peaks, nonsyllabic sounds are those that do not. Syllabic sounds are typically more prominent than contiguous nonsyllabic sounds. (Vowels, syllabic consonants vs. glides, nonsyllabic consonants.)

2. **consonantal/nonconsonantal:** [±cons]. Consonantal sounds are produced with a sustained vocal tract constriction at least equal to that required in the production of fricatives; nonconsonantal sounds are produced without such a constriction. (Obstruents, nasals, liquids vs. vowels and glides.)

3. **sonorant/obstruent:** [±son]. Sonorant sounds are produced with a vocal tract configuration sufficiently open that the air pressure inside and outside the mouth is approximately equal. Obstruent sounds are produced with a vocal tract constriction sufficient to increase the air pressure inside the mouth significantly over that of the ambient air. (Vowels, glides, liquids, nasals vs. stops and fricatives.)

4. **coronal/noncoronal:** [±cor]. Coronal sounds are produced by raising the tongue blade toward the teeth or the hard palate; noncoronal sounds are produced without such a gesture. (Dentals, alveolars, palato-alveolars, palatals vs. labials, velars, uvulars, pharyngeals.)

5. **anterior/posterior:** [±ant]. Anterior sounds are produced with a primary constriction at or in front of the alveolar ridge, while posterior sounds are produced with a primary constriction behind the alveolar ridge. (Labials, dentals, alveolars vs. palato-alveolars, palatals, velars, uvulars, pharyngeals.)

6. **labial/nonlabial:** [±lab]. As the term implies, labial sounds are formed with a constriction at the lips, while nonlabial sounds are formed without such a constriction. (Labial consonants, rounded vowels vs. all other sounds.)

7. **distributed/nondistributed:** [±distr]. Distributed sounds are produced with a constriction that extends for a considerable distance along the midsaggital axis of the oral tract; nondistributed sounds are produced with a constriction that extends for only a short distance in this direction. (Sounds produced with the blade or front of the tongue vs. sounds produced with the tip of the tongue. This feature may also distinguish bilabial sounds from labiodental sounds.)

8. **high/nonhigh:** [±high]. High sounds are produced by raising the body of the tongue toward the palate; nonhigh sounds are produced without such a gesture. (Palatals, velars, palatalized and velarized consonants, high vowels and glides vs. all other sounds.)

9. **back/nonback:** [±back]. Back sounds are produced with the tongue body relatively retracted; nonback or front sounds are produced with the tongue body relatively advanced. (Velars, uvulars, pharyngeals, velarized and pharyngealized consonants, central vowels and glides, back vowels and glides vs. all others.)

10. **low/nonlow:** [±low]. Low sounds are produced by drawing the body of the tongue down away from the roof of the mouth; nonlow sounds are produced without such a gesture. (Pharyngeal and pharyngealized consonants, low vowels vs. all others.)

11. **rounded/unrounded:** [±round]. Rounded sounds are produced with protrusion of the lips; unrounded sounds are produced without such protrusion. (Rounded consonants and vowels vs. unrounded consonants and vowels.)

12. **continuant/stop:** [±cont]. Continuants are formed with a vocal tract configuration allowing the airstream to flow through the midsaggital region of the oral tract; stops are produced with a sustained occlusion in this region. (Vowels, glides, *r*-sounds, fricatives vs. nasal and oral stops, laterals.)

13. **lateral/central:** [±lat]. Lateral sounds, the most familiar of which is [l], are produced with the tongue placed in such a way as to prevent the airstream from flowing outward through the center of the mouth, while allowing it to pass over one or both sides of the tongue; central sounds do not involve such a constriction. (Lateral sonorants, fricatives and affricates vs. all other sounds.)

14. **nasal/oral:** [±nas]. Nasal sounds are produced by lowering the velum and allowing the air to pass outward through the nose; oral sounds are produced with the velum raised to prevent the passage of air through the nose. (Nasal stops, nasalized consonants, vowels and glides vs. all other sounds.)

15. **advanced/unadvanced tongue root:** [±ATR]. As its name implies, this feature is implemented by drawing the root of the tongue forward, enlarging the pharyngeal cavity and often raising the tongue body as well; [−ATR] sounds do not involve this gesture. ([+ATR] vowels such as [i,u,e,o] vs. [−ATR] vowels such as [ɪ,ʊ,ɛ,ʌ,a].)

16. **tense/lax:** [±tense]. Tense vowels are produced with a tongue body or tongue root configuration involving a greater degree of constriction than that found in their lax counterparts; this greater degree of constriction is frequently accompanied by greater length. (Tense vowels vs. lax vowels.) We note that this feature and the last (ATR) are not known to cooccur distinctively in any language and may be variant implementations of a single feature category.

17. **strident/nonstrident:** [±strid]. Strident sounds are produced with a complex constriction forcing the airstream to strike two surfaces, producing high-intensity fricative noise; nonstrident sounds are produced without such a constriction. (Sibilants, labiodentals, uvulars vs. all other sounds.) The feature [+strid] is found only in fricatives and affricates.

18. **spread/nonspread glottis:** [±spread]. Spread or aspirated sounds are produced with the vocal cords drawn apart, producing a nonperiodic (noise) component in the acoustic signal; nonspread or unaspirated sounds are produced without this gesture. (Aspirated consonants, breathy voiced or murmured consonants, voiceless vowels and glides vs. all others.)

19. **constricted/nonconstricted glottis:** [±constr]. Constricted or glottalized sounds are produced with the vocal cords drawn together, preventing normal vocal cord vibration; nonconstricted (nonglottalized) sounds are produced without such a gesture. (Ejectives, implosives, glottalized or laryngealized consonants, vowels and glides vs. all others.)

20. **voiced/voiceless:** [±voiced]. Voiced sounds are produced with a laryngeal configuration permitting periodic vibration of the vocal cords; voiceless sounds lack such periodic vibration. (Voiced vs. voiceless consonants.)